P-WAVE VELOCITY LOGGER -- PWL

Introduction

Compressional or *P*-wave velocity (primary wave) measurements are a measure of the velocity of sound waves through earth materials, distance versus time. *P*-wave velocity varies with the lithology, porosity, and bulk density of the material; state of stress, such as lithostatic pressure; and fabric or degree of fracturing. In marine sediments and rocks, velocity values are also controlled by the degree of consolidation and lithification, fracturing, occurrence and abundance of free gas and gas hydrate. Together with density measurements, sonic velocity can be used to calculate acoustic impedance, or reflection coefficients, which can be used to estimate the depth of reflectors observed in seismic profiles.

P-wave velocity data had been collected on marine cores during the Deep Sea Drilling Project (DSDP). However, these measurements were taken at discrete locations. During the Ocean Drilling Program's (ODP) Leg 108, a prototype *P*-Wave Logger (PWL) system, developed by the Institute of Oceanographic Sciences in the United Kingdom, was deployed (Schultheiss, Meinert, et al., 1988). For the first time, higher density sampling of velocity allowed scientists to create fine-scaled velocity profiles which could be used to correlate similar horizons in adjacent holes, reveal the nature of sedimentary features and provide high-quality data for seismic interpretation.

PWL Data Acquisition

The PWL system measures the speed of compressional waves in sediments by timing the pulses traveling across the diameter of a totally full core liner. The basic parts of the PWL system include 1) a pair of spring-loaded transducers, a transmitter and a receiver, mounted on either side of the core, perpendicular to the core axis; 2) transducers to measure the displacement between the transmitter and receiver; 3) a track system that moves core past the sensors or moves the sensors along the core; and 4) computer control of data acquisition and data capture.

The prototype PWL system was mounted on the GRAPE track during Leg 108. The basic system consisted of 2 - 500 kHz transducers, displacement transducers with 0.04 mm resolution, and an analog-to-digital converter which digitized the output of the peak detector. The computer data acquisition and capture programs were modified throughout the ODP as newer technology and better data acquisition programs became available. There have also been a couple major upgrades to the PWL system during the ODP. During Leg 124E, the Geotek MST - MultiSensor Track, an automated core conveying and positioning system was installed. During Leg 187, a new analog-to-digital converter was installed that significantly changed the output recorded by the data acquisition program. A brief summary of changes to the PWL system is listed below. A comprehensive report on the first PWL system installed on Leg 108 can be found in Schultheiss and McPhail, 1989.

Table 1: P-wave Logger system summary.

Legs	Equipment	Comments
108 - 115 (Site 713)	2 - 500 kHz compressional wave transducers, electronics and computer interface	Leg 108 – PWL transducers mounted on GRAPE sample track. Leg 110 – upgraded data acquisition software. Leg 113 - new data acquisition software installed on DEC Pro350.
115 (Site 714) – 124	PWL on vertical track	PWL transducers mounted next to GRAPE source and detectors on a vertical track.
124E	MST Track – PWL	Initial installation of Geotek MST with GRA, PWL and MSL. Not all software compatible with shipboard environment, but system operational.
125 – 162	MST Track - PWL	Leg 133 - Major software upgrade; Leg 149 – NGR added to track; Leg 151 – software upgrade. No major changes to PWL system or data file format.
163 – 169 (Site 1036)	MST Track – PWL	Major software upgrade installed Leg 163 Port Call
169 (Site 1037) – 186	MST Track – PWL	Hardware and software upgrade. Leg 171 Janus database operational.
187	MST Track – PWL	Major hardware and software upgrade. Change in signal interface resulted in a major change in data format.
188 – 210	MST Track – PWL	Minor software changes during this time

Standard Operating Procedures

The basic velocity calculation is: $\boldsymbol{v = d / t}$. For laboratory measurements, the liner and the characteristics of the electronics can be sources of error in the measured velocity of the cored material. A constant liner thickness (d_{liner} - 2.54 mm, $2d_{liner}$ – 5.08 mm) was subtracted from the measured diameter, though the liner thickness could vary between 2.35 mmand 2.82 mm. There are three types of time delays that are subtracted to correct the travel time. Those are 1) t_{delay} – a delay related to the transducers and electronics; 2) t_{pulse} – a delay related to the peak detection procedure; and 3) t_{liner} – the transit time through the core liner. For routine measurements on whole cores in liners, the calculation for the velocity is:

$$v_{core} = [(d'_{core} - 2d_{liner}) / (t_0 - t_{pulse} - t_{delay} - 2t_{liner})] \times 1000,$$

where

v_{core} = corrected velocity through core (km/s),
d'_{core} = measured diameter of core and liner (mm),
d_{liner} = liner wall thickness (mm), and
t_0 = measured total travel time (μs).

The cores were stored on a rack to allow them to equilibrate to room temperature before analyzing them with the PWL. P-wave velocities are sensitive to the temperature of the core material. The highest quality velocity measurements were made on core liners that were completely full, APC cores or longer continuous hard rock cores. In order to maintain close coupling of the transducers to the core liner, the outside of the liner was sprayed with water.

After the core was placed in the track, spring-loaded transducers measured the diameter of the core. A 500 kHz pulse was produced at a repetition rate of 1 kHz. The pulse was sent to the transmitter transducer which generated an ultrasonic compressional pulse. The *P*-wave propagated through the core and was received by the receiver transducer. The amplified signal was analyzed by an automatic peak detection algorithm and generated a travel time.

Calibration

Calibration of the *P*-wave system was usually performed at the beginning of leg, but would be done after changing equipment, when transducers were showing signs of wear, or if problems were suspected. Pulse detection settings did not usually require any adjustment unless equipment was replaced or different measurement geometry was required. Pulse time was a time constant included in the total time measurement as a result of the peak detection procedure. This constant was subtracted from raw time measurements because it allowed more precise monitoring of system performance and gave measured time values that were independent of the peak detection procedure.

Transducer displacement and travel time delay calibrations were done simultaneously. This procedure was performed at least once per leg. Displacement was measured in volts. For the displacement calibration, three to four acrylic cylinder standards were measured, and a linear least-squares regression was run to determine the coefficients that relate the voltage readings to distance. A section of liner filled with distilled water (known velocity) was measured to verify that the calculated coefficients with the travel time delays return the correct velocity. After the hardware and software upgrade during Leg 187, the raw calibration data for displacement and time delay were stored in separate tables in recognition that these are two different calibrations.

Archive

Pre-Janus Archive

Most of the original PWL data files were archived on the ODP servers. There was no interim database for PWL data. In a few instances, the files for a hole were concatenated into a single file. Some of these original files are no longer available, either because the scientists who concatenated the hole file deleted them, or they were not moved onto the ODP servers.

Migration of PWL to Janus

The data model for PWL – *P*-wave Velocity Logger can be found below in Appendix I. Included are the relational diagram and the list of the tables that contain data pertinent to PWL, the column names, and the definition of each column attribute. ODP Information Services Database Group was responsible for the migration of pre-Leg 171 data to Janus. The migration of PWL velocities was done in conjunction with the other MST datasets – GRA, MSL, and NGR. Each change in format was documented and added to the MST Migration program. Additional information about the migration of PWL data or original file formats can be requested from the IODP Data Librarian.

Janus PWL Data Format

The PWL data can be retrieved from Janus Web using a predefined query. The *P*-Wave Velocity (PWL Whole-Core System) query webpage allows the user to extract data using the following variables to restrict the amount of data retrieved: leg, site, hole, core, section, specific run numbers, range in velocity values, or latitude and longitude range. In addition, the user can use the Output Raw Data option in the query to extract the raw measurements and calibration parameters used to calculate the velocity values. Because there are almost 2.6 million PWL data records in Janus, a user must restrict the amount of data requested.

The following table lists the data fields retrieved from the Janus database for the predefined PWL query with Output Raw Data option turned on. The first column contains the data item; the second column indicates the Janus table or tables in which the data were stored; the third column is the Janus column name or the calculation used to produce the value. Appendix II contains additional information about the fields retrieved using the Janus Web PWL query, and the data format for the archived ASCII files.

Table 2. PWL P-Wave Velocity query with Output Raw Data option

Item Name	Janus Table	Janus Column Name and Calculation
Leg	SECTION	Leg
Site	SECTION	Site
Hole	SECTION	Hole
Core	SECTION	Core
Type	SECTION	Core_type
Section	SECTION	Section_number
Top (cm)	PWL_SECTION_DATA	MST_Top_Interval x 100
Depth (mbsf)	DEPTH_MAP, PWL_SECTION_DATA	DEPTH_MAP.Map_Interval_Top + PWL_SECTION_DATA.MST_Top_Interval
Velocity (m/s)	PWL_SECTION_DATA	PWL_Velocity
Run Number	PWL_SECTION	Run_Number
Run Date/Time	PWL_SECTION	Run_Date_Time (yyyy-mm-dd hh:mm)
Core Status	PWL_SECTION	Core_Status
Liner Status	PWL_SECTION	Liner_Status
Liner Correction	PWL_SECTION	Liner_Correction

Item Name	Janus Table	Janus Column Name and Calculation
Requested Interval (cm)	PWL_SECTION	Requested_DAQ_Interval
Requested Sample	PWL_SECTION	Req_DAQS_per_sample
Signal Threshold	PWL_SECTION_DATA	Acoustic_signal_threshold
Core Temp (C)	PWL_SECTION_DATA	Core_temperature
Separation Mean (mm)	PWL_SECTION_DATA	Meas_separation_mean
Separation Stdev	PWL_SECTION_DATA	Meas_separation_sd
Time Mean (μs)	PWL_SECTION_DATA	Mean_time_mean
Time Stdev	PWL_SECTION_DATA	Mean_time_sd
Signal Mean	PWL_SECTION_DATA	Acoustic_signal_mean
Data acquisitions – attempted	PWL_SECTION_DATA	Attempted_DAQs
Data acquisitions – valid	PWL_SECTION_DATA	Valid_DAQs
Liner thickness (mm)	PWL_SECTION_DATA	Liner_thickness
Standard	PHYSICAL_PROPERTIES_STANDARD	Standard_name
Standard Set	PHYSICAL_PROPERTIES_STANDARD	Standard_set_name
Standard Expected	PHYSICAL_PROPERTIES_STD_DATA	Property_value
Calib Date/Time	PWL_CALIBRATION	Calibration_Date_Time (yyyy-mm-dd hh:mm)
Calib. Separation M0 (mm)	PWL_CALIBRATION	Separation _m0
Calib Separation M1 (mm/V)	PWL_CALIBRATION	Separation_m1
Calib. Separation Mean Square Error	PWL_CALIBRATION	Separation_mse
Calib. Time M0	PWL_CALIBRATION	Delay_m0
Calib. Time M1	PWL_CALIBRATION	Delay_1_over_m1
Calib. Time Mean Square Error	PWL_CALIBRATION	Delay_mse

Data Quality

There are several things that can affect the quality of PWL data. Type of material and the drilling method used to recover the core are major factors. In addition to the requirement for good acoustic coupling between the core liner and the transducers, good coupling between the core and core liner is critical for quality measurements. Soft sediment found in the top 50 m of a hole often yields good data. Below 50 m, the signal is often strongly attenuated - less cohesion of the sediments, microcracks or gas voids make good measurements impossible. The sensitivity of PWL measurements to the quality of core material means that less of the recovered core was analyzed. Table 3 summarizes how much of the different types of core were analyzed on the PWL systems.

Table 3: PWL Analysis Statistics

	Core Recovery	PWL Analyzed	Percent
APC – coretype H	113,999 meters	70,612 meters	61.9 %
XCB – coretype X	61,638 meters	8,761 meters	14.2 %
RCB – coretype R	45,869 meters	1,612 meters	3.5 %
TOTAL	222,429 meters	81,046 meters	36.4 %

One other source of error that needs to be considered is operator error. Throughout the ODP, the operator manually entered core information into the data acquisition program. Typographical errors will occasionally happen, and some mistakes will not be identified. Often, the scientific party will have found errors and corrected them for the data included in the Initial Report volume, but the original files did not get corrected. A significant amount of effort during verification of the PWL data has gone into finding sections that may have been misidentified. Some runs have been renamed to different sections, but the evidence for misidentification had to be conclusive before the runs were changed. Listed below are some of the clues used to find incorrectly identified analyses:

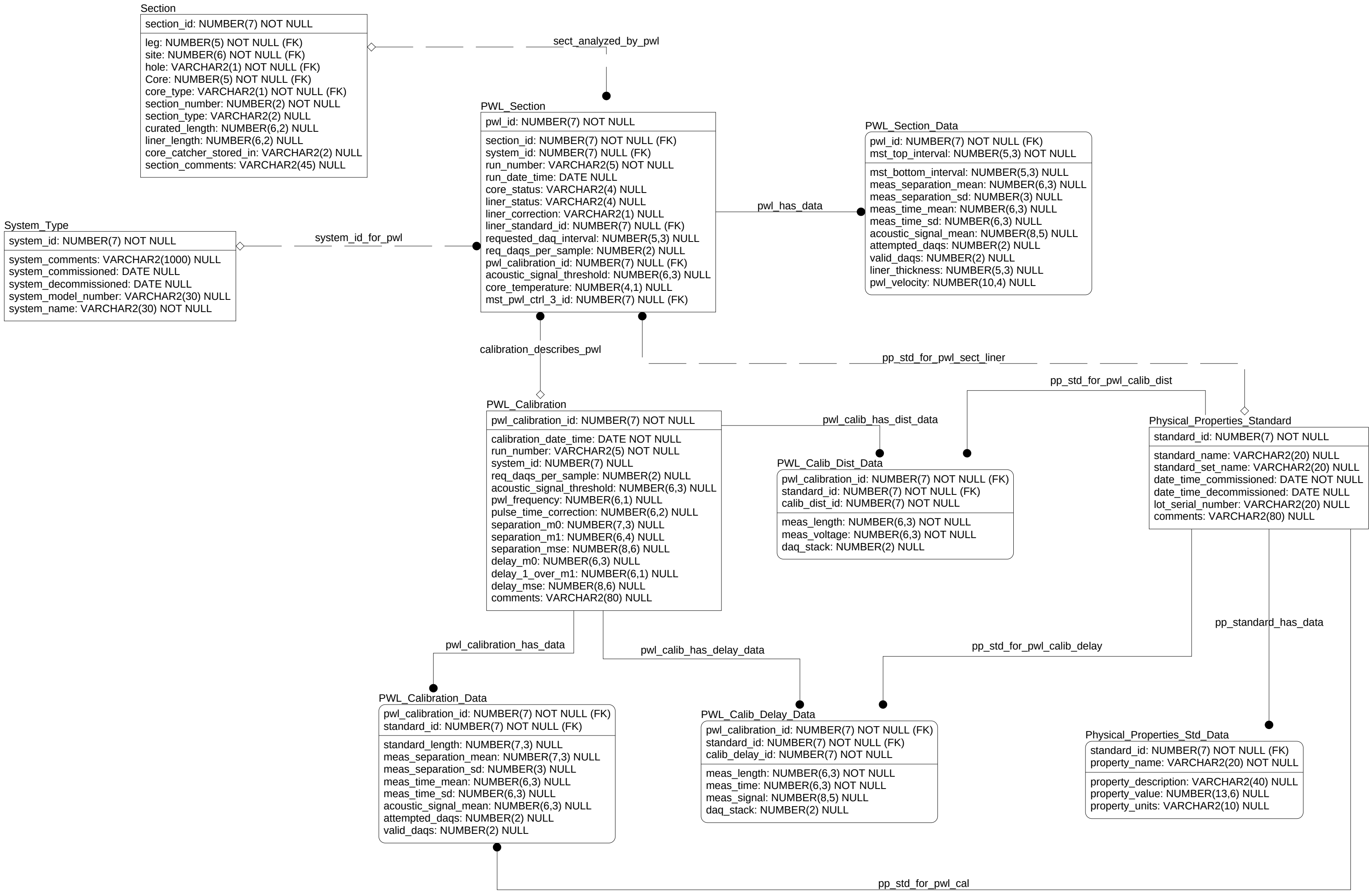
- two runs for a given section, no run for the following section;
- run numbers out of sequence;
- two runs for a section, run numbers out of sequence - no data for that core and section in a different hole, but sequence of run numbers would be correct;
- Nature of the core material – length of core, voids or less than full liners.

References

Blum, P., 1997, Physical Properties Handbook: A guide to the shipboard measurement of physical properties of deep-sea cores, ODP Tech. Note 26.

Schultheiss, P.J. and McPhail, S.D., 1989, An Automated P-Wave Logger for Recording Fine-Scale Compressional Wave Velocity Structures in Sediments. *In* Ruddiman, W., Sarnthein, M., et al., *Proc. ODP, Sci. Results,* 108: College Station, TX (Ocean Drilling Program, 407-413.

Schultheiss, P.J., Meinert, J., and Shipboard Scientific Party, 1988. Whole-core *P*-wave velocity and gamma ray attenuation logs from Leg 108 (Sites 657 through 668). *In* Ruddiman, W. , Sarnthein, M., et al., *Proc. ODP, Init. Repts.*, 108, Sect. 2: College Station, TX (Ocean Drilling Program), 1015-1046.


Section
section_id: NUMBER(7) NOT NULL
leg: NUMBER(5) NOT NULL (FK)
site: NUMBER(6) NOT NULL (FK)
hole: VARCHAR2(1) NOT NULL (FK)
Core: NUMBER(5) NOT NULL (FK)
core_type: VARCHAR2(1) NOT NULL (FK)
section_number: NUMBER(2) NOT NULL
section_type: VARCHAR2(2) NULL
curated_length: NUMBER(6,2) NULL
liner_length: NUMBER(6,2) NULL
core_catcher_stored_in: VARCHAR2(2) NULL
section_comments: VARCHAR2(45) NULL
sect_analyzed_by_pwl
PWL_Section
pwl_id: NUMBER(7) NOT NULL
section_id: NUMBER(7) NOT NULL (FK)
system_id: NUMBER(7) NULL (FK)
run_number: VARCHAR2(5) NOT NULL
run_date_time: DATE NULL
core_status: VARCHAR2(4) NULL
liner_status: VARCHAR2(4) NULL
liner_correction: VARCHAR2(1) NULL
liner_standard_id: NUMBER(7) NULL (FK)
requested_daq_interval: NUMBER(5,3) NULL
req_daqs_per_sample: NUMBER(2) NULL
pwl_calibration_id: NUMBER(7) NULL (FK)
acoustic_signal_threshold: NUMBER(6,3) NULL
core_temperature: NUMBER(4,1) NULL
mst_pwl_ctrl_3_id: NUMBER(7) NULL (FK)
pwl_has_data
PWL_Section_Data
pwl_id: NUMBER(7) NOT NULL (FK)
mst_top_interval: NUMBER(5,3) NOT NULL
mst_bottom_interval: NUMBER(5,3) NULL
meas_separation_mean: NUMBER(6,3) NULL
meas_separation_sd: NUMBER(3) NULL
meas_time_mean: NUMBER(6,3) NULL
meas_time_sd: NUMBER(6,3) NULL
acoustic_signal_mean: NUMBER(8,5) NULL
attempted_daqs: NUMBER(2) NULL
valid_daqs: NUMBER(2) NULL
liner_thickness: NUMBER(5,3) NULL
pwl_velocity: NUMBER(10,4) NULL
System_Type
system_id: NUMBER(7) NOT NULL
system_comments: VARCHAR2(1000) NULL
system_commissioned: DATE NULL
system_decommissioned: DATE NULL
system_model_number: VARCHAR2(30) NULL
system_name: VARCHAR2(30) NOT NULL
system_id_for_pwl
calibration_describes_pwl
pp_std_for_pwl_sect_liner
pp_std_for_pwl_calib_dist
PWL_Calibration
pwl_calibration_id: NUMBER(7) NOT NULL
calibration_date_time: DATE NOT NULL
run_number: VARCHAR2(5) NOT NULL
system_id: NUMBER(7) NULL
req_daqs_per_sample: NUMBER(2) NULL
acoustic_signal_threshold: NUMBER(6,3) NULL
pwl_frequency: NUMBER(6,1) NULL
pulse_time_correction: NUMBER(6,2) NULL
separation_m0: NUMBER(7,3) NULL
separation_m1: NUMBER(6,4) NULL
separation_mse: NUMBER(8,6) NULL
delay_m0: NUMBER(6,3) NULL
delay_1_over_m1: NUMBER(6,1) NULL
delay_mse: NUMBER(8,6) NULL
comments: VARCHAR2(80) NULL
pwl_calib_has_dist_data
PWL_Calib_Dist_Data
pwl_calibration_id: NUMBER(7) NOT NULL (FK)
standard_id: NUMBER(7) NOT NULL (FK)
calib_dist_id: NUMBER(7) NOT NULL
meas_length: NUMBER(6,3) NOT NULL
meas_voltage: NUMBER(6,3) NOT NULL
daq_stack: NUMBER(2) NULL
Physical_Properties_Standard
standard_id: NUMBER(7) NOT NULL
standard_name: VARCHAR2(20) NULL
standard_set_name: VARCHAR2(20) NULL
date_time_commissioned: DATE NOT NULL
date_time_decommissioned: DATE NULL
lot_serial_number: VARCHAR2(20) NULL
comments: VARCHAR2(80) NULL
pp_standard_has_data
pwl_calibration_has_data
pwl_calib_has_delay_data
pp_std_for_pwl_calib_delay
PWL_Calibration_Data
pwl_calibration_id: NUMBER(7) NOT NULL (FK)
standard_id: NUMBER(7) NOT NULL (FK)
standard_length: NUMBER(7,3) NULL
meas_separation_mean: NUMBER(7,3) NULL
meas_separation_sd: NUMBER(3) NULL
meas_time_mean: NUMBER(6,3) NULL
meas_time_sd: NUMBER(6,3) NULL
acoustic_signal_mean: NUMBER(6,3) NULL
attempted_daqs: NUMBER(2) NULL
valid_daqs: NUMBER(2) NULL
PWL_Calib_Delay_Data
pwl_calibration_id: NUMBER(7) NOT NULL (FK)
standard_id: NUMBER(7) NOT NULL (FK)
calib_delay_id: NUMBER(7) NOT NULL
meas_length: NUMBER(6,3) NOT NULL
meas_time: NUMBER(6,3) NOT NULL
meas_signal: NUMBER(8,5) NULL
daq_stack: NUMBER(2) NULL
Physical_Properties_Std_Data
standard_id: NUMBER(7) NOT NULL (FK)
property_name: VARCHAR2(20) NOT NULL
property_description: VARCHAR2(40) NULL
property_value: NUMBER(13,6) NULL
property_units: VARCHAR2(10) NULL
pp_std_for_pwl_cal

APPENDIX 1: Janus Data Model – PWL Velocity

***P*-Wave Velocity Logger – PWL**		
Table Name	**Column Name**	**Column Comment**
PWL_Section	pwl_id	Unique Oracle-generated sequence number for each PWL analysis run.
	section_id	Unique Oracle-generated sequence number to identify each section.
	system_id	Unique identifier for a system of equipment used to collect data.
	run_number	Number identifying a run generated by the data acquisition software. This number is not used to identify the run in Janus because it may not be unique.
	run_date_time	Timestamp when analysis was run.
	core_status	Indicates if a full or half (split) core is being analyzed. Valid values are FULL or HALF.
	liner_status	Records if a core liner was present, a split liner or no liner. Valid values are FULL, HALF and NONE.
	liner_correction	Y or N if liner correction used.
	liner_standard_id	A nullable role of the standard ID attribute used for the liner.
	requested_daq_interval	Sampling interval requested for section analysis, in cm.
	req_daqs_per_sample	Requested number of data measurements taken per sample interval.
	pwl_calibration_id	Unique Oracle-generated sequence number for each velocity calibration recorded for the PWL instrument.
	acoustic_signal_threshold	The strength of the acoustic signal for a velocity measurement. Valid values 0 -255. This was changed from N(3) to N(4,3) by Bill Mills in Feb. 2000 because of PWL hardware upgrade.
	core_temperature	Temperature of the core in ^{o}C.
	mst_pwl_ctrl_3_id	Unique Oracle-generated sequence number for each PWL control_3 analysis.

PWL_Section_Data	pwl_id	Unique Oracle-generated sequence number for each PWL analysis run.
	mst_top_interval	The top interval of a measurement in meters measured from the top of a section.
	mst_bottom_interval	The bottom interval of a measurement in meters measured from the top of a section.
	meas_separation_mean	The average measured separation of a pair of transducers. Valid values 0-255. Changed to N(6,3) in August 2000 because of PWL hardware upgrade and change in data acquisition software.
	meas_separation_sd	The standard deviation of the measured separation for a pair of transducers.
	meas_time_mean	The average time measured for a signal to travel between transducers for a velocity measurement, in microseconds.
	meas_time_sd	The standard deviation of the measured time for a signal to travel between a pair of transducers, in microseconds.
	acoustic_signal_mean	The mean value of the acoustic signal from a velocity measurement. Valid values 0-255 in bytes - changed to N(6,3) in August 2000 because of a change in the data acquisition code.
	attempted_daqs	Number of attempted data acquisitions
	valid_daqs	Number of valid data acquisitions from those attempted.
	liner_thickness	Thickness of the liner in mm. If liner correction = N then this value is set to zero or null.
	pwl_velocity	Published velocity in m/sec. Velocity values stored when there is not enough information to calculate velocity from raw values and calibration factors.

PWL_Calibration	pwl_calibration_id	Unique Oracle-generated sequence number for each velocity calibration recorded for the PWL instrument.
	calibration_date_time	Time stamp identifying when calibration was done - supplied by instrument data files.
	run_number	Number identifying a run generated by the data acquisition software. This number is not used to identify the run in Janus because it may not be unique.
	system_id	Unique identifier for a system of equipment used to collect data.
	req_daqs_per_sample	The requested number of data acquisitions to be taken per sample interval.
	acoustic_signal_threshold	The strength of the acoustic signal for a velocity measurement used Valid values 0 -255. This was changed from N(3) to N(4,3) by Bill Mills in Feb. 2000 because of PWL hardware upgrade.

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Table Name	Column Name	Column Comment
	pwl_frequency	Frequency of P-wave transducers, in kHz.
	pulse_time_correction	Time delay related to threshold peak detection procedure, in microseconds.
	separation_m0	Calculated distance calibration constant, in millimeters.
	separation_m1	Calculated distance calibration slope, in millimeters/volts.
	separation_mse	Mean square error in distance calibration constant calculation.
	delay_m0	Calculated time calibration constant, in microseconds.
	delay_1_over_m1	Calculated time calibration slope, in microseconds/millimeter. Changed name from delay_1_m1 to delay_1_over_m1, Dec. 2000.
	delay_mse	Mean square error from time calibration line.
	Comments	General comments

PWL_Calibration_ Data	pwl_calibration_id	Unique Oracle-generated sequence number for each velocity calibration recorded for the PWL instrument.
	standard_id	Identifier for a physical properties standard.
	standard_length	Length of the standard, in millimeters.
	meas_separation_mean	The average measured separation of a pair of transducers. Valid values 0-255.
	meas_separation_sd	The standard deviation of the measured separation for a pair of transducers.
	meas_time_mean	The average time measured for a signal to travel between transducers for a velocity measurement, in microseconds.
	meas_time_sd	The standard deviation of the measured time for a signal to travel between a pair of transducers, in microseconds.
	acoustic_signal_mean	The mean value of the acoustic signal from a velocity measurement.
	attempted_daqs	Number of attempted data acquisitions.
	valid_daqs	Number of valid data acquisitions from those attempted.

PWL_Calib_Delay_ Data	pwl_calibration_id	Unique Oracle-generated sequence number for each velocity calibration recorded for the PWL instrument.
	standard_id	Identifier for a physical properties standard.
	calib_delay_id	Unique Oracle-generated sequence number for each delay calibration record for the PWL instrument.
	meas_length	Length of standard, in millimeters.
	meas_time	Measured time, in microseconds.
	meas_signal	Signal level, in volts.
	daq_stack	Number of valid data acquisitions.

PWL_Calib_Dist_ Data	pwl_calibration_id	Unique Oracle-generated sequence number for each velocity calibration recorded for the PWL instrument.
	standard_id	Identifier for a physical properties standard.
	calib_dist_id	Unique Oracle-generated sequence number for each distance calibration record for the PWL instrument.
	meas_length	Length of standard, in millimeters.
	meas_voltage	Signal level, in volts
	daq_stack	Number of valid data acquisitions.

Physical_Properties_ Standard	standard_id	Identifier for a physical properties standard.
	standard_name	Name of a physical properties standard.
	standard_set_name	The name for a set of physical properties standards.
	date_time_commissioned	The date that a physical properties standard went into use.
	date_time_decommissioned	The date that a physical properties standard’s use was discontinued.
	lot_serial_number	Information concerning the lot and/or serial number associated with a physical properties standard.
	Comments	General comments

Physical_Properties_ Std_Data	standard_id	Identifier for a physical properties standard.
	property_name	A property associated with a physical properties standard, for example ‘material’ or ‘density.’
	property_description	A description of a property associated with a physical properties sample.

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Table Name	Column Name	Column Comment
	property_value	The value of a property associated with a physical properties standard.
	property_units	The units associated with a property for a physical properties standard.

Section	section_id	Unique Oracle-generated sequence number to identify each section. This is done because of the physical subsection / zero section problems. In adding new sections, deleting sections or changing sections - don't want to have to renumber.
	leg	Number identifying the cruise for which data were entered into the database.
	site	Number identifying the site from which the core was retrieved. A site is the position of a beacon around which holes are drilled.
	hole	Letter identifying the hole at a site from which a core was retrieved or data were collected.
	Core	Sequential numbers identifying the cores retrieved from a particular hole. Cores are generally 9.5 meters in length, and are numbered serially from the top of the hole downward.
	core_type	A letter code identifying the drill bit/coring method used to retrieve the core.
	section_number	Cores are cut into 1.5 m sections. Sections are numbered serially, with Section 1 at the top of the core.
	section_type	Used to differentiate sections of core (S) from core catchers (C). Previously core catchers were stored as section number CC, but in Janus core catchers are given the next sequential number from the last section recovered.
	curated_length	The length of the section core material, in meters. This may be different than the liner length for the same section. Hard rock cores will often have spacers added to prevent rock pieces from damaging each other.
	liner_length	The original length of core material in the section, in meters. Sum of liner lengths of all the sections of a core equals core recovery.
	core_catcher_stored_in	Sometimes the core catcher is stored in a D tube with a section. core_catcher_stored_in contains the section number of the D tube that holds the core catcher.
	section_comments	Comments about this section.

System_Type	system_id	Unique identifier for a system of equipment used to collect data.
	system_comments	Comments associated with a piece of analytical equipment
	system_commissioned	Date that a piece of equipment started to be used to collect scientific data for the ODP.
	system_decommissioned	Date that a piece of analytical equipment was no longer used by ODP.
	system_model_number	The model number of a piece of equipment used for scientific analysis.
	system_name	The name for a piece of equipment used for analysis.

Appendix II: Description of data items from PWL query.

Column Name	Column Description and Calculation	Format
Leg	Number identifying the cruise. The ODP started numbering the scientific cruises of the *JR* at Leg 101. A leg was nominally two months duration. During the 18+ years of the ODP, there were 110 cruises on the *JR*.	Integer 3
Site	Number identifying the site. A site is the location where one or more holes were drilled while the ship was positioned over a single acoustic beacon. The *JR* visited 656 unique sites during the course of the ODP. Some sites were visited multiple times, including some sites originally visited during the Deep Sea Drilling Program for a total of 673 site visits.	Integer 4
Hole	Letter identifying the hole. Multiple holes could be drilled at a single site by pulling the drill pipe above the seafloor, moving the ship some distance away and drilling another hole. The first hole was designated 'A' and additional holes proceeded alphabetically at a given site. Location information for the cruise was determined by hole latitude and longitude. During ODP, there were 1818 holes drilled or deepened.	Text 1
Core	Cores are numbered serially from the top of the hole downward. Cored intervals are up to 9.7 m long, the maximum length of the core barrel. Recovered material was placed at the top of the cored interval, even when recovery was less than 100%. More than 220 km of core were recovered by the ODP.	Integer 3
Type	All cores are tagged by a letter code that identifies the coring method used.	Text 1
Section	Cores are cut into 1.5 m sections in order to make them easier to handle. Sections are numbered serially, with Section 1 at the top of the core. PWL measurements were made on sections. Core Catcher sections identified as "CC".	Integer 2 (Text 2)
Top (cm)	The top interval of a measurement in centimeters measured from the top of a section.	Decimal F4.1
Depth (mbsf)	Distance in meters from the seafloor to the sample location.	Decimal F7.3
Velocity (m/s)	Calculated compressional velocity in meters per second.	Decimal F10.4
Run Number	Number generated by the data acquisition software, to identify an analysis run of a section of core.	Text 5
Run Date/Time	Timestamp identifying when analysis was run.	Text 16 (yyyy-mm-dd hh:mi)
Core Status	Indicates whether a whole or half (split) core is being analyzed. Valid values are FULL or HALF.	Text 4
Liner Status	Records if a core liner was used, a split liner or no liner. Valid values are FULL, HALF and NONE.	Text 4
Liner Correction	Y or N if liner correction used.	Text 1
Requested Interval (cm)	Sampling interval requested for section analysis in cm.	Decimal F5.3
Requested Sample	Requested number of data measurements taken per sample interval.	Integer 2
Signal Threshold	The strength of the acoustic signal for a velocity measurement. Valid values 0 -255. This was changed from N(3) to N(4,3) Feb. 2000 because of PWL hardware upgrade.	Decimal F4.3
Core Temp (C)	Temperature of the core in ^{o}C.	Decimal F4.1

Column Name	Column Description and Calculation	Format
Separation Mean (mm)	The average measured separation of a pair of transducers. Valid values 0-255. Changed to N(6,3) in August 2000 because of a change in the data acquisition code.	Decimal F6.3
Separation Stdev	The standard deviation of the measured separation for a pair of transducers.	Integer 3
Time Mean (ms)	The average time measured for a signal to travel between transducers for a velocity measurement, in microseconds.	Decimal F6.3
Time Stdev	The standard deviation of the measured time for a signal to travel between a pair of transducers, in microseconds.	Decimal F6.3
Signal Mean	The mean value of the acoustic signal from a velocity measurement. Valid values 0-255 in bytes - changed to N(6,3) in August 2000 because of a change in the data acquisition code.	Decimal F8.5
Data acquisitions – attempted	Number of attempted data acquisitions.	Integer 2
Data acquisitions – valid	Number of valid data acquisitions from those attempted.	Integer 2
Liner thickness (mm)	Thickness of the liner in mm. If liner correction = No then this value is set to zero.	Decimal F5.3
Standard	Name of a physical properties standard.	Text 20
Standard Set	The name for a set of physical properties standards.	Text 20
Standard Expected	The value of a property associated with a physical properties standard.	Decimal F13.6
Calib Date/Time	Timestamp identifying when calibration was run.	Text 16 (yyyy-mm-dd hh:mi)
Calib. Separation M0 (mm)	Calculated distance calibration constant in millimeters.	Decimal F7.3
Calib Separation M1 (mm/V)	Calculated distance calibration slope, in millimeters per volts	Decimal F6.4
Calib. Separation Mean Square Error	Mean square error in distance calibration constant calculation	Decimal F8.6
Calib. Time M0	Calculated time calibration constant, in microseconds.	Decimal F6.3
Calib. Time M1	Calculated time calibration slope, in microseconds/millimeter. Changed name from delay_1_m1 to delay_1_over_m1, Dec. 2000.	Decimal F6.1
Calib. Time Mean Square Error	Mean square error from time calibration line.	Decimal F8.6